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Effectiveness of Sex Pheromone in Controlling Cocoa Pod Borer, *Conopomorpha cramerella* (Snell.)

Keefektifan Feromon Seks untuk Mengendalikan Hama Penggerek Buah Kakao, Conopomorpha cramerella (*Snell.*)

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Abstract

Cocoa pod borer (CPB, *Conopomorpha cramerella* Snell.) is a dangerous pest of cocoa which seriously reduce cocoa production mainly in Southeast Asia and Pasific. Prevention of CPB attack can be done by pod sleeving to prevent CPBs lay eggs on pod, or reduction of source of CPB infestation by using pheromone or kairomone as attractant in an insect trap. A preliminary research using sex pheromone has been conducted at endemic cocoa area infested by CPB in East Java. The objective of this study was to evaluate the effectiveness of sex pheromones in controlling CPB. Trial was arranged by randomized completely block design in four treatments and four blocks as replication. Four densities trap/ha (0, 4, 8, and 12 traps/ha) were used as a treatments. Sex pheromone trap consisted of synthetic pheromone (lure) and sticky liner was hanged on 0.5 m above the cocoa canopy. The results showed that the number of CPB captured during four months was significantly decreased. The number of CPB captured per trap during the first two months in the treatment of 0, 4, 8 and 12 traps/ha were 0, 6.5, 4.72, and 5.58 CPBs, respectively. Four months after treatment, the number of CPB captured in the respective treatments was reduced to 0, 0.25, 0.6, and 0.96 CPBs. Estimate calculation on yield loss due to CPB attack showed that before treatment the yield loss ranged 37.4–45.6%, however six months after treatment, the yield loss in treatment plots decreased to 9.4–21%, whereas on control 38.47%. Use of sex pheromones to attract CPB at a density of 4 traps/ha reduced yield losses due to CPB damage by 67.7%. The significant correlation between the number of CPB captured with the damage intensity followed regression equation of Y = - 0,00044X + 0,32059. Use of sex pheromone for monitoring or mass trapping of CPB, as a component in IPM of CPB is promising, due to its nature for specific target, environmentally friendly, effectiveness, and economic values.

Key words: cocoa, cocoa pod borer, *Conopomorpha cramerella*, integrated pest management, biological control, sex pheromone

Abstrak

Penggerek buah kakao [*PBK,* Conopomorpha cramerella (*Snell.*)] *merupakan hama utama tanaman kakao yang berbahaya karena dapat menurunkan produktivitas kakao, utamanya di Asia Tenggara dan Pasifik. Pencegahan serangan PBK dapat dilakukan dengan teknik penyarungan buah agar serangga PBK tidak dapat bertelur pada buah kakao, atau dengan mengurangi sumber infestasi PBK melalui pemasangan perangkap* (trapping) *menggunakan feromon seks atau kairomon. Penelitian dilakukan di pertanaman kakao endemik PBK di Kabupaten Trenggalek, Jawa Timur. Penelitian ini bertujuan untuk mengetahui keefektifan senyawa feromon seks dalam mengendalikan PBK. Penelitian dirancang dalam rancangan acak kelompok (RAK) dengan empat perlakuan dan empat ulangan. Empat variasi kerapatan perangkap, yaitu 0, 4, 8, dan 12 perangkap per hektar digunakan sebagai perlakuan. Bahan terdiri dari perangkap segitiga, lure* (*feromon seks*)*, tiang penyangga, tali plastik dan perekat dipasang 0,5 m di atas kanopi tanaman kakao. Hasil penelitian menunjukkan bahwa jumlah serangga PBK yang terperangkap selama empat bulan secara nyata menurun. Jumlah PBK terperangkap per trap selama dua bulan pertama pada perlakuan 0, 4, 8, dan 12 perangkap/ha berturut-turut adalah 0; 6,5; 4,7; dan 5,6 ekor. Empat bulan setelah perlakuan, jumlah PBK yang terperangkap menurun menjadi 0; 0,3; 0,6; dan 0,9 ekor per trap. Hasil perhitungan pendugaan kehilangan hasil akibat serangan PBK menunjukkan bahwa sebelum perlakuan kehilangan hasil berkisar 37,4–50,3%, namun enam bulan setelah perlakuan, kehilangan hasil dalam plot perlakuan menurun menjadi 9,4–21,4%, sedangkan pada kontrol mencapai 38,4%. Pemanfatan feromon seks untuk pengendalian PBK dengan kepadatan empat perangkap/ha dapat mengurangi kehilangan hasil sebesar 75,5% dibanding kontrol. Terdapat korelasi yang nyata antara jumlah PBK tertangkap dengan intensitas kerusakan, mengikuti persamaan regresi Y = - 0,00044 X + 0,32059. Penggunaan feromon seks untuk monitoring atau penangkapan massal PBK, sebagai salah satu komponen dalam PHT PBK cukup menjanjikan, karena sifatnya spesifik sasaran, ramah lingkungan, efektif, dan ekonomis.*

Kata kunci: *kakao, penggerek buah kakao,* Conopomorpha cramerella*, pengendalian hama terpadu, pengendalian hayati, seks feromon*

INTRODUCTION

Indonesia is the third cocoa producer in the world after Cote d'ivoire and Ghana with total area was 1.75 million ha in 2011/ 2012 and production was 833,310 ton (Ditjenbun, 2012). In the Asia Pasific Region about 79.5% of cocoa beans was from Indonesia, mostly from Sulawesi. During 2003–2009 period, cocoa productivity in Indonesia especially on smallholder was declining. Main factors contributing to the declining in productivity were old trees, destruction of crop conditions, most plants are not productive, as well as infection of vascular-streak dieback (VSD) disease caused by the fungus *Oncobasidium theobromae*, pod rot, and CPB.

Cocoa pod borer (CPB), *Conopomorpha cramerella* (Snellen) (Lepidoptera: Gracillariidae) is the serious pest of cocoa which seriously reduce cocoa production mainly in Southeast Asia (Mumford, 1984) and Pasific (Sulistyowati, 2006, Gende, 2007). Yield losses due to the CPB is 25–30% that equivalent to US$ 200 million/year (ACDI/VOCA, 2004). It is reasonal that

problem of CPB is threatening the sustainability of cocoa production and quality. Control methods for suppressing CPB in Indonesia are undertaken based on the integrated pest management (IPM) implementation, such as pruning of canopy, frequent harvesting (7–14days), sanitation through burrying cocoa pod husks, or using biological control agents, etc. (Sulistyowati & Wiryadiputra, 2008). Biological control of CPB has been practiced using *Beauveria bassiana* (entomopathogen), black ants, *Dolichoderus thoracicus,* although there are still many factors influencing its effectiveness in the field, especially on mass production technique and quality control. Pod sleeving with plastic bags reduces invasion of pods by CPB. Spraying of pods and branches with a synthetic pyrethroid is considered a last resort for very serious infestations.

Prevention of CPB attack can be done by pod sleeving to prevent CPBs lay eggs on pod, or reduction of source of CPB infestation by using pheromone or kairomone as attractant in an insect trap. Breevor *et al*. (1986) have conducted analysis on volatile compounds that released by female CPB. Analyses of ovipositor washing and entrained volatiles from virgin female moths by gas chromatography (GC) linked to electroantennography (EAG), and comparison of EAG responses from the male moth to synthetic compounds indicated the presence of the E,Z,Z and E,E,Z isomers of 4,6,10-hexadecatrienyl acetate and the corresponding alcohols, and of hexadecyl alcohol. Amount of pheromone produced was less than 0,1 µg/female. Evaluation on the effectiveness of CPB pheromones has been conducted by National Resource Institute, USA and its field test has been conducted in Malaysia and Indonesia (Zhang, 2006). In Malaysia, synthetic pheromones can be caught more than 100 CPBs in one week (Maysin, personal communication), whereas in goverment estate in East Java 6-25 CPB can be caught weekly (Sulityowati, 2007). The study of mating disruption using synthetic sex pheromone has been done by Alias *et al*. (2004). The results showed that ratio of copulation of female insects *C. cramerella* trapped were reduced between 80-90% compared to control a month after treatment. Thereafter, synthetic CPB sex pheromone was produced in a large scale by Pest Control India (PCI), India. The objective of this study was to evaluate the effectiveness of synthetic sex pheromones in trapping CPB for population monitoring as well as for controlling CPB.

MATERIAL AND METHODS

The research was conducted at small-holder cocoa endemic of CPB area in Trenggalek distict,East Java. The material of sex pheromone compounds (lure) EAPs were used in this study produced by Pest Control India. Composition of lure formulation was developed by Breevor *et al.* (1986) which consists of EZZ and EEZ isomers of 4,6,10-Hexadecatrienyl Acetate, relatives of alcohol (corresponding alcohols), and hexadecyl alcohol. Trial was arranged by randomized completely block design in four treatments and four blocks as replication. Four trap densities (0, 4, 8, and 12 traps/ha) were used as a treatments. Sex pheromone trap consisted of CPB lure and sticky liner was hanged on 0.5 m above the cocoa canopy. Traps were placed around individual farms of about 0,5 ha size each, at a density of 0, 4, 8, and 12 traps/ ha placed traps in a grid. Assessment was carried out at monthly on the number of CPB captured and damage intensity of pod infested by CPB before treatment and two harvest periods after treatment. The damage intensity of CPB was divided in four catagories i.e healthy pod, light damage (< 10% of the beans are unextractable);

moderate damage (10–50% of the beans are unextractable) and heavy damage (> 50% of the beans are unextractable).

Yield losses due to CPB was estimated using linier regression equation (Wardani *et al*., 1997):

$$Y = - 0,0210 + 0,1005 X$$

Note:
- Y : yield losses due to CPB
- X : Score of damage intensity {(0* number of healthy pods + 1* number of slightly damage pods + 3* number of moderate damage pods + 9* number of heavy damage pods))/totally pods observed}

RESULTS AND DISCUSSION

Effect on CPB captured

The results showed that synthetic pheromone developed by Breevor *et al.* (1986) which consists of EZZ and EEZ isomers of 4,6,10 - Hexadecatrienyl Acetate, relatives of alcohol (corresponding alcohols), and hexadecyl alcohol caught the moths of *C. cramerella*. The number of CPB captured per trap during the first two months in the treatment of 0, 4, 8 and 12 traps/ha was 0, 6.5, 4.72, and 5.58 CPBs, respectively. The number of CPB trapped during four months after treatment was significantly decreased. The number of CPB captured in the respective treatments was reduced to 0, 0.25, 0.6, and 0.96 CPBs per trap.

The number of male CPB captured in these trial was lower than the results trial was conducted by Breevor *et al*. (1986). The number of male CPB catch/trap/night in traps baited with synthetic pheromone (E,Z,Z4,6,10-16:Ac + E,E,Z4,6,10-16:Ac + E,Z,Z4,6,10-16:OH + E,E,Z4,6,10-16:OH + 16: OH in 40:60:4:6:10 ratio) was 12.9 higher than number of male CPB catches in baited traps with virgin female moth (0.97 moth catch/trap/night). It means that synthetic pheromone more effective to attract males CPB than pure pheromone of virgin CPB females. Breevor (1986) found that amount of pheromone produced were less than 0.1 µg/ female. Observation on the number of male CPB captured at different control methods plot was conducted during 2005–2006 in Sabah, Malaysia by Zhang *et al.* (2006). The results showed that CPB population could be greatly influenced by different control methods. Trap captures of male CPB were significantly higher in sites applying pod sleeving alone and normal agronomic practices than that of site using egg parasitoid and pod sleeving combination. However, CPB captures in all of three sites were significantly lower than in site treated with pesticides. These suggested that pesticides might have reduced the natural enemies and other beneficial insect's populations in the ecosystem with repeated use of the same class of pesticides. The substantial differences in the trap captures between sites treated with normal agronomic practices and cocoa black ant to against CPB population in Peninsular, West Malaysia also clearly showed that the biological control agent was able to

Table 1. CPB captured per trap on 2, 3, dan 4 months after installation of pheromone traps

Table 1. Jumlah ngengat PBK terperangkap pada 2,3, dan 4 bulan setelah pemasangan perangkat feromon seks

ΣTraps/ha	Number of CPB captured/trap (months after treatment) *Jumlah CPB tertangkap/trap* (*bulan setelah perlakuan*)		
	2 months (*bulan*)	3 months (*bulan*)	4 months (*bulan*)
0 trap/ha	0.00 a	0.00 a	0.00 a
4 trap/ha	6.50 a	0.38 b	0.25 a
8 trap/ha	4.72 a	1.38 b	0.60 a
12 trap/ha	5.58 a	1.31 b	0.69 a

Means in the same coloumn followed by the same letter are not significantly different; LSD test, P = 0.05 (*Dalam kolom yang sama diikuti oleh huruf yang sama tidak berbeda nyata; uji LSD, P = 0,05*).

reduce CPB population more efficiently than that of normal agronomic practices.

Effect on infestation and yield loss

Preliminary observations on percentage of CPB damage and yield losses due to CPB was known that the percentage of CPB damage was ranged from 72 to 95% and yield losses from 37.4 to 50.5%, there were no significant differences between densities pheromone trap treatments (Table 2). Observation results of CPB damage and yield loss calculation were conducted on six months after sex pheromone trap installed. It was known that the percentage of yield loss due to CPB was significantly decreassing. There was no significantly differences between treatment on the percentage of CPB damage, but there were significantly differences on yield loss between treatments and control, but no significantly differences between densities pheromone trap treatments.

The average of percentage of CPB damage on 6 months after pheromone treatment was ranged from 61.5 to 72.6% and there is no significant difference among treatments. Based on the percentage of CPB damage, not so apparent decrease, but in terms of percentage yield losses results, the apparent decline, from 37.4 to 50.5% decreased to 9.4–21.4% at which the pheromone treatment results in loss of control achieved 38.4%. The effectiveness of density treatment of 4 pheromone traps per hectare compared to control was 67,7%.

Table 2. CPB damage and yield loss due to CPB on preliminary observations before installation pheromone sex

Table 2. Persentase serangan akibat PBK dan hasil hilang sebelum perlakuan

ΣTraps/ha	CPB Infestation, %	Yield losses, %
0	71.75 a	45.55 a
4	95.00 a	50.33 a
8	78.84 a	50.50 a
12	80.00 a	37.39 a

Means in the same coloumn followed by the same letter are not significantly different; LSD test, P = 0.05 (*Dalam kolom yang sama diikuti oleh huruf yang sama tidak berbeda nyata; uji LSD, P = 0,05*).

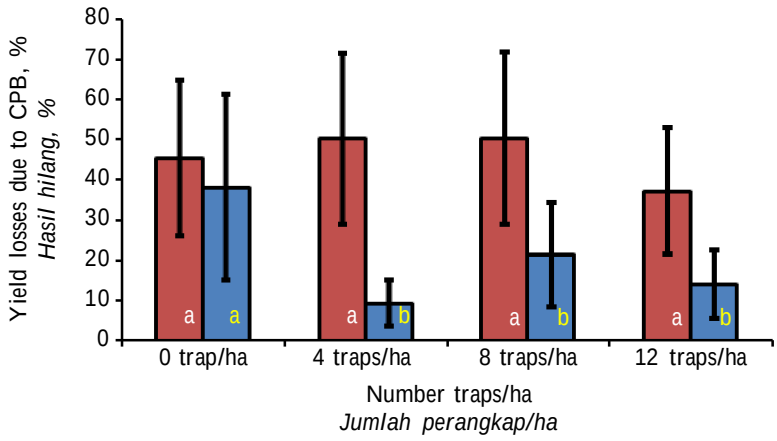

Figure 1. Yield loss due to CPB before instalation (red) and sixth month after installation (blue) of sex pheromone traps

Gambar 1. Kehilangan hasil akibat serangan PBK sebelum perlakuan (merah) dan enam bulan setelah pemasangan (biru) perangkat feromon seks

There was significant correlation between the number of CPB trapped with the damage intensity of CPB. The correlation between number of CPB captured and damage intensity followed the regression equation of Y = - 0,00044X + 0,32059. It means that more higher male CPBs captured in the synthetic pheromone trap was affected the declining of CPB damage intensity. With so many male insects caught in pheromone traps, affecting in decreased fertilization of CPB female insects, so the number of eggs produced by CPB was low

Previously, studies on pheromones were conducted in small-holder farms in Noling, Sulawesi. The effect of mass trapping and pesticide sprays alone or in combination were all better than the untreated control plots in reducing percentage of damaged pods, improving the percentage of uninfested good quality cocoa pods and increasing the weight of "commercially" usable beans. Particularly, there was no significant differences between pesticide and pheromone treatments. Thus, the pheromone lure appeared to be as effective as synthetic pesticides (Hebbar *et al*., 2008). Several small scale (Beevor *et al*, 1986) and large scale (Beevor *et al*, 1993) experimental field trials were done in Sabah for several years, with promising results. In large-scale (200 ha) trials conducted at BAL plantations in Malayasia, a 30% reduction in pod damage was observed (Zhang *et al*., 2006). Based on these results,the synthetic sex pheromone will enable possible future development of mating disruption and attract-and-kill technologies for managing CPB populations. To achieve better results and reduce costs of application, it is recommended that this technology should be used by farmers collectively.

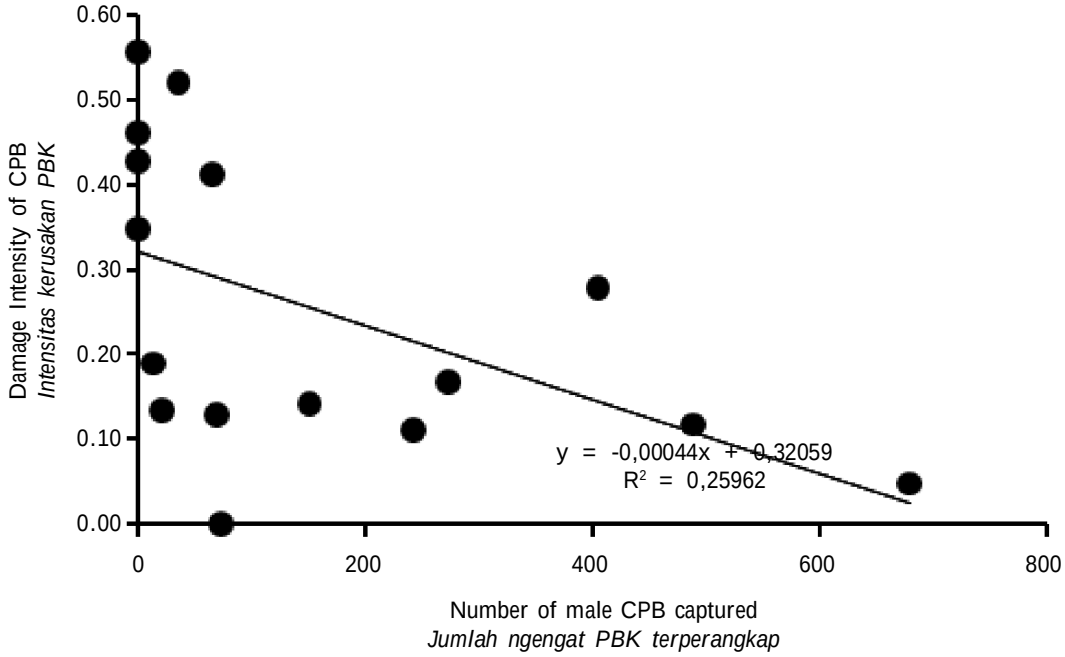

Figure 3. Correlation between number of CPB captured and damage intensity due to CPB
Gambar 3. Korelasi antara jumlah ngengat PBK terperangkap dengan intensitas kerusakan akibat PBK

CONCLUSION

- Use of sex pheromones to attract CPB at a density of 4 traps/ha can reduce yield losses 67.7%.
- Use of sex pheromone for monitoring or mass trapping of CPB, as a component in IPM of CPB is promising, due to its nature for specific target, environmentally friendly, effectiveness, and economic values.

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